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High Temperature Destruction of Hazardous Waste Practice, Performance, Prospects

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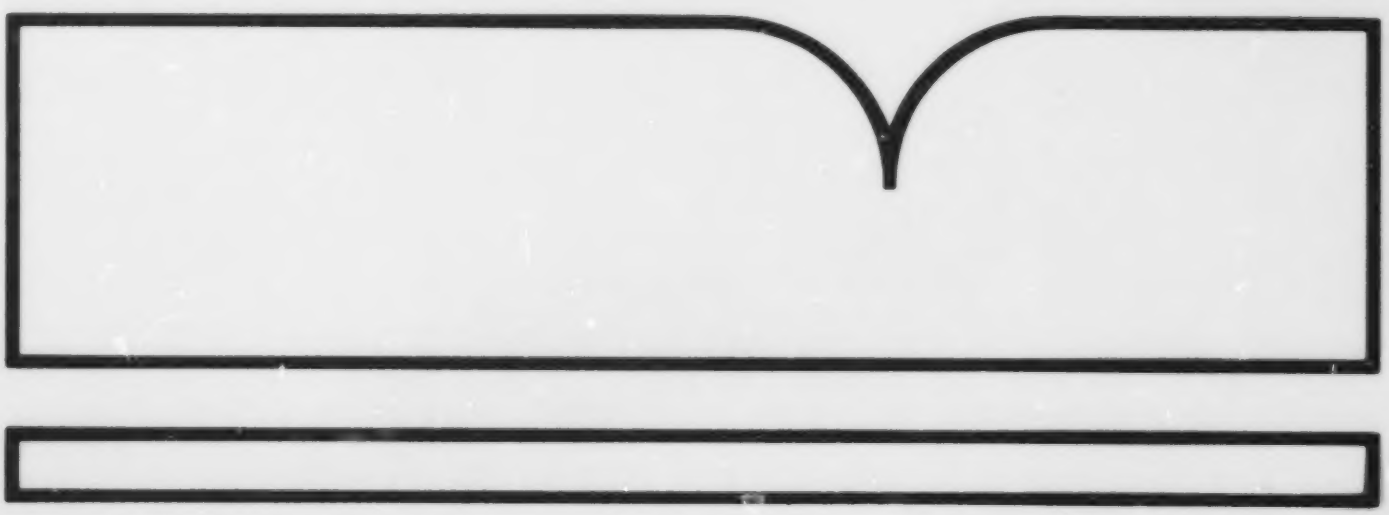

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HIGH TEMPERATURE DESTRUCTION OF HAZARDOUS WASTE
PRACTICE, PERFORMANCE, PROSPECTS

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Current EPA regulatory activities center on prohibition of hazardous wastes from land disposal. The promulgation of these regulations is expected to put increased emphasis on high temperature destruction methods, although the rate of these changes will be highly susceptible to many market factors, public acceptance and the specific regulations themselves.

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ABSTRACT

This paper discusses the practice of destroying hazardous waste by incineration and other high temperature processes, the research that has been performed in this area, and the future plans and prospects associated with these activities.

The results of the research program to date have indicated that, in general, properly operated, high temperature processes can attain Environmental Protection Agency (EPA) standards for destruction and removal of organics contained in the tested hazardous waste (destruction and removal efficiency greater than 99.99%). Effective control (99% removal) of HCl emissions was also attained in facilities handling chlorinated organic waste. The EPA standard for particulates (180 mg/dry m^3) was the most difficult to achieve. Several of the tested facilities contained particulates in stack gas at significantly higher concentrations.

Current EPA regulatory activities center on prohibition of hazardous wastes from land disposal. The promulgation of these regulations is expected to put increased emphasis on high temperature destruction methods, although the rate of these changes will be highly susceptible to many market factors, public acceptance and the specific regulations themselves.

PAST AND CURRENT PRACTICE

Background

Thermal destruction of hazardous waste involves the controlled exposure of waste to high temperature (usually 900°C or greater), and typically, an oxidizing environment. Thermal destruction processes include: thermal oxidation, starved air, or pyrolytic incineration systems; high temperature industrial processes such as boilers, cement kilns, and industrial furnaces where hazardous waste is employed as a fuel; and various emerging processes which employ high temperatures, such as molten salt, molten glass, plasma-arc electric furnaces, etc.

Properly designed and operated thermal destruction systems offer the prospect of destroying the hazardous organic components of waste streams while reducing waste volume and, in some instances, recovering energy or materials such as hydrochloric or sulfuric acid. Because of this, thermal destruction systems have emerged over the past decade as an increasingly desirable alternative to the more traditional hazardous waste disposal methods of landfilling, lagooning, and deep well injection (1).

However, improper design and operation of thermal hazardous waste destruction systems may also pose a threat to public health through emissions of potentially hazardous components of the waste or their combustion by-products. It was the recognition of the inherent environmental advantages of waste thermal destruction, balanced against the potential problems of improper design and operation that lead the U.S. Environmental Protection Agency (EPA) to develop performance standards and permit requirements for thermal destruction systems under the Resource Conservation and Recovery Act of 1976 (RCRA). Standards for incinerators have been in place since June 1982 and standards are currently under development for disposal of hazardous wastes in industrial processes.

It is anticipated that thermal destruction will become even more important in the future as EPA responds to the U.S. Congressional mandate to restrict many hazardous wastes from land disposal and to effect corrective action at abandoned and uncontrolled disposal sites under the Comprehensive Environmental Response, Compensation and Liability Act of 1980 (CERCLA). Of the many thermal processes in various stages of development in the country today, there are only five technologies that have been used to treat significant amounts of hazardous waste. These are liquid injection incinerators, rotary kiln incinerators, industrial boilers, cement kilns, and ocean incinerator ships.

Current Practice

The most recent complete data on hazardous waste thermal destruction practices come from EPA surveys of industry activity in 1981. Since then, partial surveys have been made and significant efforts are presently underway to determine capacity for various treatment and disposal methods. These efforts are to provide data for determining exemptions to the RCRA amendments in excluding

hazardous wastes from further disposal on land, deep well injection, etc. Results from these efforts are not yet available. The U. S. Environmental Protection Agency (EPA) has estimated that the United States generated 264 million metric tonnes (MMT) of hazardous waste in 1981 (2). A significant portion of this waste was predominently non-hazardous material (water, inorganics, etc.)) contaminated with hazardous materials. While only a relatively small amount of hazardous waste was managed by thermal destruction (Table 1), EPA estimates that as much as 25 MMT per year could have been thermally destroyed. In reality, the organic portion of virtually any waste material is amenable to thermal destruction. Thus, considerably more waste could have been directed to thermal destruction processes than the 25 MMT/yr estimate (3).

It is also significant to note that more than twice as much hazardous waste was burned in industrial processes as fuel, as compared to that disposed in specially designed incineration systems.

Table 1. Hazardous Waste Thermal Destruction Facilities (1981)

Thermal Destruction Facility	Waste (MMT/yr)*	Major Waste Types (by volume)
Incinerators (240 facilities)	1.70	Non-halogenated solvents, corrosives, reactive wastes
Industrial Boiler (1300 facilities)	3.50	Organic solvents, ignitable wastes
Other (kiln, etc.)	0.35	Organic solvents
	5.55	

*MMT/yr = million metric tonnes per year

Incinerator Practice in the U.S.

Incineration and other thermal processes have been used as a final treatment or disposal method for hazardous wastes in the United States for approximately two decades. In 1984, it was estimated that there were some 230 industrial or government owned incinerators which incinerated about 1.70 million metric tons of hazardous wastes per year.

According to EPA's information (4) about 80 percent of the existing 230 incinerators are privately owned and operated, while 20 percent are commercial or military operations. That is, 80 percent are primarily dedicated to incinerating wastes from the private industrial companies which own and operate these incinerators on their own property. As to the generic designs of all incinerators, EPA believes that about 48 percent are liquid injection units, 19 percent are fixed hearths, 6 percent are rotary kilns, and 27 percent are various military, fluid

bed, or undertermined designs at this point. Additionally, the majority of units have been installed within the past ten or fifteen years. The median capacity of individual incinerators for liquids is 150 gallons per hour, while the median capacity of solids units is about 650 pounds per hour (1). A summary of incinerator practices determined by a 1981 study appears in Table 2.

Table 2. United States Hazardous Waste Incineration Practices (1981).(5,6)

OWNERSHIP:	80% Private 20% commercial and military
WASTE:	77% of facilities handle on-site wastes only 79% of units - liquids only 11% of units - bulk wastes (solids and liquids) 10% of units - special purpose
EQUIPMENT:	48% are liquid injection units 19% are fixed hearth units 6% are rotary kiln or combination units 27% are other (military , fluid bed, etc.) 45% have air pollution control systems 22% employ heat recovery
OPERATIONS:	median - 982°C (1800°F) at 2 seconds residence time (gas) range - 649°C (1200°F) - 1260°C (2300°F) 0.1 seconds - 6.5 seconds residence time most operate on an intermittent schedule
CAPACITY:	median - liquids, 567.8 l/hr (150 gal/hr) solids, 294.8 kg/hr (650 lb/hr) range - .317 - 150 x 10^9 (0.3 - 142 x 10^6 Btu/hr) .075 - 35.78 x 10^6 KCal/hr
MANUFACTURING:	57 companies actively marketing incinerators 28 companies sold units most units installed since 1970 32-40 units under construction

PERFORMANCE TEST RESULTS

Since 1980, the Office of Research and Development (ORD), the Office of Water (OW), and the Office of Solid Waste (OSW) have cooperated in conducting performance tests of over 40 full-scale hazardous waste thermal destruction facilities in the United States. The data from these tests have been utilized extensively in defending current Resource Conservation and Recovery Act (RCRA) regulations and standards, in developing proposed standards and in preparing Regulatory Impact Analysis (RIA) related to hazardous waste thermal destruction. These studies have lead EPA to conclude that well operated incinerators, industrial

boilers, and cement kilns are capable of achieving or exceeding 99.99 percent Destruction and Removal Efficiency (DRE) of the principal organic hazardous constituents (POHCs) in hazardous wastes. All facilities tested usually attained the RCRA standard for removal of hydrochloric acid (HCl) from stack emissions. OSW conducted risk assessment of the emissions from incinerators tested by ORD and concluded in their RIA that residual organic compounds posed no sigfnificant health risk.

Tables 3, 4 and 5 describe the facilities and waste types encompassed by the test program and summarize waste destruction and emission performance data. All of the incinerators tested achieved 99.99 percent DRE for candidate POHC compounds in concentrations greater than 1000 parts per million (ppm) in the waste feed. Candidate POHC compounds below 500 ppm were not always destroyed to the 99.99 percent level. This phenomenon, which was also observed in tests of other thermal destruction devices, was unexpected. A number of possible explanations have been advanced.

To demonstrate 99.99 DRE at very low POHC concentrations (less than 500 ppm), stack emission concentrations of less than 50 parts per billion (ppb) have to be measured. Sampling and analysis techniques may be the limiting factor, skewing these measurements toward higher readings in some cases.

Also, at these low emission levels, sufficient amounts of a POHC may actually be formed as an incomplete combustion or recombination by-product of other organics or materials in the wastes which in sum produces less than 99.99 percent DRE.

EPA is conducting research to further assess this concentration effect phenomenon. From a regulatory standpoint, however, this is not currently perceived as a problem since few if any of the low concentration compounds in the wastes identified in the EPA test program would have actually been selected as POHCs in trial burns, if the existing EPA guidance on POHC selection were employed. Cement kilns, lime kilns, and light weight aggregate kilns with adequate combustion control and waste atomization all met or exceeded the 99.99 percent DRE. It is also important to note that for all of the incinerators and industrial processes tested, the destruction (D) and the removal (R) efficiencies observed were due to destruction rather than removal or capture of hazardous organics. Ash, scrubber water, and air pollution control device residues were typically below detection limits for POHCs and organics in general. All incinerators and industrial process kilns tested met or approached the RCRA HCl removal standard. Industrial boilers typically have no existing controls for HCl, but none exceeded the 1.8 Kg/hr (4 lb/hr) emission standard since wastes with low net chlorine content were employed (6).

Achieving the particulate emission standard was a problem for a number of the incinerators tested. In one test program, four of the eight units failed to meet the RCRA standard. Two of those facilities were marginally above the emission limit. They might be likely to meet the standard with minor operating adjustments or with other state-of-the-art control devices added. The remaining two facilities appeared to need significant design and/or operational changes.

TABLE 3--INCINERATOR PERFORMANCE AND STACK EMISSIONS DATA

FACILITY TYPE	O_2 (%)	CO (ppm)	THC (ppm)	DRE(a) (NUMBER OF NINES)	PARTICULATE (mg/m^3)	HCl CONTROL
(1) Commercial Rotary Kiln/ Liquid Incinerator	10.5	<1.0-14.8	<1.0	5.3	1508	99.4%
(2) Commercial Fixed Hearth, Two Stage Incinerator	11.4	4.7 9.1	1.0	4.4	400	98.3%
(3) On-site Two-Stage Liquid Incinerator	8.3	9.9-11.2	3.9-8.9	4.4	61	99.7%
(4) Commercial Fixed Hearth, Two-Stage Incinerator	11	7.5 22.2	<1.0 1.9	4.7	200	<1.8 kg/hr
(5) On-Site Liquid Injection	12.1	6.7 19.3	<1.0	6.7	207	<1.8 kg/hr
(6) Commercial Two-Stage	9.9	<1.0 1.8	<1.0	4.3	900	<1.8 kg/hr
(7) On-Site Rotary Kiln	9.7	422-666	47.6-75.9	5.3	23	99.9%
(8) Commercial Two-Stage Fixed Hearth Incinerator	13.6	0.9-4.3	0.8-2.5	4.6	169	98.3%

(a) mass weighted overages for all POHCs >100 ppm in waste
4.5 nines = 99.995% DRE

TABLE 4--SUMMARY OF BOILER PERFORMANCE (6)

Facility Type	Load (%)	O_2(%)	Residence Time (sec)	Average Volumetric Heat Release Rate KW//m^3	DRE[d] (No. Nines)	W/F[a] (%)	NO_x[b] (ppm)	CO[b] (ppm)
(1) Watertube Stoker	100	6-16	1.2	509	3.8	40	163-210	900-1200
(2) Packaged Firetube	25	4-6	0.8	739	4.1	0.1-05	40-65	47-88
(3) Field Erected Watertube	26	10	2	78	5.6	37	61-96	18-21
(4) Converted Stoker	78	4-6	1.1	339	4.8	18-48	193-250	75-127
(5) Packaged Watertube	36-73	6-7	0.5-1.1	960	4.5	19-56	164-492	83-138
(6) Converted Watertube	53	7-11	2	107	3.8	8.7-10.1	243-328	109-139
(7) Modified Firetube	44	8	0.4	807	4.8	100	67-74	146-170
(8) Tangentially Fired Watertube	100	6	2	180	4.1	2.4-4.3	393-466	142-201
(9) Packaged Watertube	65	2	1.8	343	4.8	8.2	64-78 410-1125[c]	46-750
(10) Packaged Firetube	50-100	3-8	0.3-0.7	1240	5.0	100	85-203	20-135
(11) Packaged Watertube	82	4	1.8	269	5.7	49	154-278	102-119

(a) W/F = waste heat input as a % of total heat input
(b) range of average values across individual sites and runs including baseline
(c) higher values are for high nitrogen waste firing
(d) DRE = destruction and removal efficiency (e.g., 4.5 nines = 99.995% DRE)

TABLE 5--SUMMARY OF INDUSTRIAL KILN PERFORMANCE (6)

FACILITY TYPE	TEST[a]	DRE[b] (NO. NINES)	PARTICULATES[d] (kg/Mg)	HCl (kg/hr)	NO_x (ppm)	SO_2 (ppm)	W/F (%)[c]
(1) Wet Process Cement Kiln (Non-atomized Waste)	W	2.2	.27	.36	68	450	25
	B	-	.26	.09	136	279	-
(2) Wet Process Cement Kiln (Atomized Waste)	W	4.6	.27	2.1	478	265	15
	B	-	.26	.6	371	636	-
(3) Dry Process Cement Kiln (Non-atomized Waste)	W	4.8	-	11.5	814	19	45
	B	-	-	1.3	620	7	-
(4) Dry Process Cement Kiln (Atomized Waste)	W	4.2	-	.47	486	27	15
	B	-	-	.25	680	27	-
(5) Lime Kiln (Atomized Waste)	W	4.7	.11	.20	446	596	30
	B	-	.10	.09	386	553	-
(6) Shale Aggregate Kiln (Atomized Waste)	W	>4.0	.33	2.1	-	-	100
(7) Clay Aggregate Kiln (Atomized Waste)	W	4.8	0.5	0.023	162	1130	59
(8) Clay Products Kiln (Atomized Waste)	W	>4.0	.002	0.84	-	-	100

(a) W = waste testing, B = baseline (no waste firing)

(b) DRE = destruction and removal efficiency (e.g., 4.5 nines = 99.995%)

(c) % of total heat input provided by waste fuel

(d) Stack emissions of particulate matter expressed as kg of emission per Mg of clinker produced

This general trend is consistent with the results of RCRA permit trial burns conducted for other incineration facilities over the past two years. No significant changes in particulate emissions were observed for industrial boilers and certain of the industrial process kilns when they fired kCRA waste fuels. Some increased emissions were observed in kilns employing electrostatic precipitators (ESP) for particulate control. These increases were attributed to changes in the electrical resistivity of the particles due to the presence of increased chloride levels. Adjustments in ESP operation might correct this in most cases.

Products Of Incomplete Combustion (PICs) (5).

The current RCRA standards regulate destruction and removal only for the major hazardous compounds in the waste. Under poor combustion conditions, many compounds may only partially decompose and form products of incomplete combustion (PICs) which are also hazardous compounds of concern if emitted. For the purpose of the EPA test program, compounds were considered to be PICs if they were regulated organic compounds (i.e., listed in Appendix VIII of CFR 40 Part 261) (7) which were detected in stack emissions, but not present in the waste feed at concentrations greater than 100 ppm. The PICs most frequently identified in the EPA testing of incinerators and industrial boilers were benzene, chloroform, and tetrachloroethylene (Table 6). At this writing, detailed PIC analyses have been completed for only three cement kiln tests. The most common PICs identified during the kiln tests were benzene, benzaldehyde, toluene, and various naphthalenes.

Analysis Of The Pooled Data (6)

The incinerator test program revealed that there was no narrow band or finite level of mean combustion temperature, mean gas phase residence time or carbon monoxide emission concentration which correlated with achieving 99.99 percent DRE. Residence times ranged from 0.1 to 6.5 seconds in the facilities tested. Temperatures ranged from 648°C to 1450°C. Carbon monoxide (CO) levels were as high as 600 ppm, but at most plants ranged from 5 ppm to 15 ppm. It appears to EPA at this time that the relationships between DRE and these parameters are in all likelihood facility specific and that waste characteristics, waste atomization, and combustion chamber mixing likely play an equally important role in achieving high DRE. Timing, funding, and facility constraints did not allow for colletion of sufficient performance data under varying conditions at each site tested to allow for such relationships to be quantified. EPA is continuing to add new test results and information from permit trial burns and from testing at EPA pilot-scale and full scale research facilities to the data base in an effort to better predict DRE from process parameters.

WHERE ARE WE NOW, WHERE ARE WE GOING?

Prospects For Thermal Destruction

The prospects for increased utilization of thermal destruction processes for hazardous waste disposal are significant. Incineration is considered a proven,

TABLE 6--PICs MOST FREQUENTLY DETECTED IN STACK EMISSIONS (5)

PIC	NUMBER OF FACILITIES	CONCENTRATION (ng/l)
Incinerators		
Benzene	6	12-670
Chloroform	5	1-1,330
Bromodichloromethane	4	3-32
Dibromochloromethane	4	1-12
Naphthalene	3	5-100
Bromoform	3	0.2-24
Chlorobenzene	3	1-10
Tetrachloroethylene	3	0.1-2.5
1,1,1-Trichloroethane	3	0.1-1.5
Toluene	2	2-75
o-Nitrophenol	2	25-50
Methylene chloride	2	2-27
Phenol	2	4-22
Boilers		
Chloroform	5	4.2-1900
Tetrachloroethylene	5	0.3-760
Chloromethane	4	4.6-410
Methylene chloride	4	83-2000
Benzene	3	9.4-270
1,1,1-Trichloroethane	3	5.9-270
1,2-Dichloroethane	3	1.3-1200
1,1-Dichloroethylene	2	0.21-38
1,1,2,2-Tetrachloroethane	2	4.6-16
Toluene	2	46-960

commercially-available technology which has been demonstrated to be suitable for accommodating a wide range of organic wastes. Industrial high-temperature processes also can be suitably modified to destroy certain types of hazardous wastes (particularly combustible liquids) while recovering energy.

Thermal destruction is currently used to manage only about 2 percent of hazardous wastes generated annually. Many of the remaining wastes are being directed to land disposal facilities. However, the recently promulgated Hazardous and Solid Waste Amendments of 1984 (RCRA Amendments), with their sweeping provisions to restrict many wastes from land disposal, will prompt more intense consideration of thermal destruction as a control option. If it is assumed that the regulations are implemented immediately and current incineration capacity does not increase at the same time, a number of demand distributions, beyond existing capacity, can be estimated, as shown in Table 7.

TABLE 7 - Excess of Demand Over Existing Incineration Capacity (expressed as a % of current capacity) (8)

Regulatory Scenario	On-site[a]	Off-site[b]
-Landfill Restrictions	40%	215%
-Deep Well Injection Restrictions	54%	306%
-Disposal Impoundments Prohibitions	52%	288%
-Waste-In-Boilers Restrictions	42%	106%

[a] Facilities on company land accepting only waste generated by that company "on-site."

[b] Facilities whose primary purpose is to accept wastes from numerous generators.

Additional listings of hazardous wastes and lowering the small generator exemption (also part of the RCRA amendments) could have further effects on the demand for incineration. However, these are not projected in this analysis.

Using the projections of excess demand for commercial incineration created by the four regulatory changes, estimations of incinerator equivalents that would be required in order to meet such demand can be drawn. Such projected excess demand could be met by either 82 additional land-based incinerators (20,000 metric ton per year average capacity), or 33 additional incinerator ships (50,000 metric ton per year average capacity) (8).

Kilns and other high temperature industrial processes have a significant potential capacity to dispose of hazardous waste which will become available due to

the regulatory impacts projected. The tempering effect on the willingness of owners of these facilities to accept these wastes for thermal destruction and heat recovery (in some cases) will be the degree to which the waste is suitable for the process. It is anticipated that significant amounts of the waste diverted from restricted disposal methods will have less energy value, contain a higher ash, solids and water content, and produce compatibility problems with the process and/or the process equipment. The EPA has begun concentrated effort in evaluating and defining methods of pre-treatment which could make more of the diverted waste compatible with existing high temperature industrial processes.

Permitting and siting difficulties are significant impediments to the development of commercial incinerator capacity as well as the use of various industrial processes for waste destruction. Consequently, available commercial incineration capacity is likely to grow little over the short-term. A three to five year lag-time is possible before significant new capacity could be available. Many believe that the use of mobile incinerators or larger, transportable units is one way of mitigating the public opposition which frequently plagues permanent centralized incineration facilities. While a number of mobile systems have been proposed, most are still developmental at this point. Little actual field testing has been done beyond that underway on an EPA-owned mobile rotary kiln incinerator and a similar commercial unit. The EPA unit has been tested for PCB carbon tetrachloride destruction and, most recently, the successful incineration of dioxin-contaminated soils in Missouri (5).

Problems To Be Solved. Thermal destruction is a widely applicable technology for management of organic hazardous waste. Associated with the use of this technology is a slate of technical, socio-economic and political problems that need to be resolved before the technology can be fully implemented. Some of the major points that EPA is addressing are discussed in the following.

Waste Characterization and Classification. While many wastes have been well tested and characterized, many still are not. This is especially true for more complex wastes which will emerge as candidates for thermal destruction due to the new regulations. Information on pre-treatment requirements, impact on processes, "incinerability" data, emission control data and residue handling and treatment will be required.

PICs. Products of incomplete combustion or recombination need to be further tested, measured and minimized for new wastes and new processes. In previous testing, EPA has detected these compounds at concentrations similar to the residual POHCs in the stack effluents when the processes were achieving high levels of destruction efficiency. The existance of PICs has created concern within the public sector. This concern has required the EPA to provide more detailed studies of PIC emissions to allay the concerns raised by this issue. These studies have taken the form of basic research, to understand the mechanisms of PIC formation, and PIC control, through optimization of combustion conditions and definition of off-design operating envelopes that produce unacceptable levels of PICs.

Heavy Metals. The presence of heavy and toxic metals in hazardous waste creates a special problem. Metals, such as arsenic, chromium, lead, zinc, etc. are not destroyed by high temperature processes, but rather are vaporized, liberated, oxidized or recombined with the waste ingredients and discharged as ash trapped at the air pollution control equipment (as solid or liquid matter) or passed into the air.

To deal with these wastes effectively, EPA believes that pretreatment methods need to be evaluated and developed for removing the metals. Similarly, organometalic compounds (e.g. sodium cyanide, zinc-based pesticides, etc.) may be difficult to destroy and/or may result in the destruction of the organic fraction but liberation of the metallic elements. More information is needed (1).

Acutely Hazardous Waste. Additional work is needed regarding the incineration of chemical compounds considered to be "acutely" hazardous such as many of the chlorinated dioxins and furans. Although these compounds have been incinerated successfully in low concentrations to date, additional testing is required with increased detection limit capability and under varied conditions (e.g., absorbed in waste soils, in high concentrations, etc.) to build confidence that these toxic compounds can be effectively destroyed by incineration (5).

Process Monitoring. While tests at full scale facilities and trial burn tests for incinerator permit applications have shown that most thermal destruction facilities achieve required levels of organic hazardous waste destruction, off-design operation, resulting in process upsets or failure modes may result in significantly lower DREs. Research is needed to determine the impact of such failure modes and to provide real time, cost effective, destruction performance monitoring instrumentation for informing plant operators, and enforcement officials of non-compliance conditions and for signaling immediate corrective action is required.

Further, this information is needed to allay the concerns of the public for the continuing safe operation of the permitted hazardous waste destruction facilities.

Ongoing Research

The EPA's Office of Research and Development, is working closely with the Office of Solid Waste,the Office of Water, the Office of Enforcement, the Office of Toxic Substances, and the Regional Offices to address the issues surrounding the thermal destruction of hazardous waste. Performance testing is being conducted at full-scale incinerators, industrial boilers, and other industrial processes (batch asphalt plants) to assess metal emission and off-design or failure conditions. The data are to be used by the Office of Solid Waste to finalize possible metal emission standards and rules for use by industrial boilers and kilns and other processes for cofiring of hazardous waste.

A significant portion of the needed research is being conducted at EPA facilities. The Combustion Research Facility (CRF) in Arkansas houses two, fully permitted, pilot-scale incinerators which can be used to conduct controlled experiments on processes failure modes, metal partitioning, compliance monitoring methods, PIC formation, and incinerability studies on problem wastes from Superfund sites. This work is directed and optimized by the results of smaller-scale experiments in facilities in Cincinnati (Center Hill) and Research Triangle Park, North Carolina (RTP). Here bench and laboratory combustion systems are designed to isolate the significance of important thermal destruction phenomena upon process failure, performance indicator compounds and PICs. These facilities include experimental equipment to assess: waste atomization (RTP); solids decomposition and volatization (RTP); quenched flame phenomena (Center Hill); post-flame thermal decomposition/recombination (Center Hill); flame and burner and effects (Center Hill). At Edison, New Jersey, the Release Control Branch conducts programs using a mobile incinerator to test the feasibility to detroy spilled hazardous wastes. The remainder to the research is performed under contract as part of the extramural program or as Interagency Agreements (IAGs).

The conclusions drawn from the research performed to date are that the high temperature destruction of hazardous waste is an effective method of dealing with the problem if certain pre[illegible]ions are observed. Certain waste types (such as those containing heavy metals) are not well suited for the present technology and must be treated or pretreated by other methods. More information is needed to fill the holes within the generally explored research matrix. New methods have to be developed to deal with the pressure of new and larger amounts of wastes that will vie for high temperature destruction. Cost effective and reliable monitoring methods need to be developed that insure proper operation and convince a skeptical public that these methods are safe and, especially, safer than the alterntives.

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